REMARKS

Claims 7, 8, and 10 to 12, as amended, appear in this application for the Examiner's review and consideration. Claim 9 is canceled by this Amendment without prejudice. The amendments are fully supported by the specification and claims as originally filed. Therefore, there is no issue of new matter.

Claims 7 to 12 stand rejected under 35 U.S.C. § 103(a), as allegedly being unpatentable over Japanese Application Publication No. JP 10-176239 to Kashima et al. (Kashima), for the reasons set forth on pages 2 to 5 of the Office Action; and

Claims 7 to 12 stand rejected under 35 U.S.C. § 103(a), as allegedly being unpatentable over Japanese Application Publication No. 2003-096545 to Kami et al. (Kami), for the reasons set forth on pages 5 to 6 of the Office Action.

In response, Applicants submit herewith a second Declaration under 37 C.F.R. 1.132 of Dr. Hitoshi Asahi, a co-inventor of the presently claimed steel pipe. The Rule 132 Declaration of Dr. Asahi sets forth the differences between the presently claimed steel pipe and the steel pipe disclosed by the cited references.

The presently claimed invention is directed to steel pipe formed from a plate of a steel base material. The steel base material comprises, by mass %, C: 0.03 to 0.30%, Si: 0.01 to 0.8%, Mn: 0.3 to 2.5%, P: 0.03% or less, S: 0.01% or less, Al: 0.001 to 0.1%, N: 0.01% or less, and a balance of iron and unavoidable impurities. The steel base material has a dual-phase structure substantially comprising ferrite structure and fine martensite dispersed at the ferrite grain boundaries.

A steel pipe, formed from a plate of the steel base material, heated at the austenite-ferrite dual-phase temperature region and then quenched, where the heating and quenching are after the plate of the steel base material is shaped into the pipe, has a ratio of the proportional limit of the compression stress-strain curve in the circumferential direction before and after expansion of at least 0.7.

That is, after a plate of the steel base material is shaped into the pipe, the steel pipe is heated at the austenite-ferrite dual-phase temperature region, and then quenched, and the heated and quenched steel pipe has a ratio of the proportional limit of the compression stress-strain curve in the circumferential direction before and after expansion of at least 0.7.

As discussed by Dr. Asahi in his Rule 132 Declaration, the Office Action states that the word "small" in the recitation in the claims of a "small occurrence of the Bauschinger effect" is a relative term hat is not defined, such that, without establishing a standard for the

term "small," the Office Action finds it is unclear how data can be compared to demonstrate a significant difference between the presently claimed steel pipe and the pipe disclosed in the cited prior art references.

In response to those statements in the Office Action, the claims have been amended to delete "small occurrence of the Bauschinger effect," and to add the recitation that a steel pipe, formed from a plate of the steel base material, heated at the austenite ferrite dual phase temperature region and then quenched, where the heating and quenching are after the plate of the steel base material is shaped into the pipe, has a ratio of the proportional limit of the compression stress-strain curve in the circumferential direction before and after expansion of at least 0.7.

As discussed by Dr. Asahi in his Rule 132 Declaration, <u>after</u> the plate of the steel base material is shaped into the steel pipe, the steel pipe is heated at the austenite-ferrite dual-phase temperature region and then quenched, and the ratio of proportional limit of the compression stress-strain curve in the circumferential direction of the steel pipe before expansion of the steel pipe and after expansion of the steel pipe strain is at least 0.7 m where the ratio of the proportional limit is (PL-a)/(PL-b), where (PL-a) is the proportional limit yield strength after expansion of the steel pipe, and (PL-b) is the proportional limit yield strength before expansion of the steel pipe using a 0.05 percent offset yield strength.

The ratio of the proportional limit, (PL-a)/(PL-b), is called the "Bauschinger effect ratio." With a greater value of the ratio of the proportional limit, (PL-a)/(PL-b), the occurrence of the Bauschinger effect is less. *See*, the present specification, page 8, lines 5 to 8. Experimentally obtained values of the proportional limit ratio, i.e., the Bauschinger effect ratio, are provided in Table 4 of the present specification.

The steel pipe of the present invention, having an occurrence of the Bauschinger effect that is less than that of prior art steel pipe, is a steel pipe wherein, <u>after</u> a steel plate is shaped into the steel pipe, the steel pipe is heated at the austenite-ferrite dual-phase temperature region, and then quenched. There is no prior art disclosure of a steel pipe formed in the manner used to produce the steel pipe of the invention.

In contrast to the presently claimed steel pipe, Kashima discloses a steel plate for use in forming steel pipe that may be similar in composition to the steel base material of the present invention, but Kashima does not disclose or suggest that <u>after</u> a steel plate is shaped into a steel pipe, the steel pipe should be heated at the austenite-ferrite dual-phase temperature region and then quenched to obtain a ratio of the proportional limit of the

compression stress-strain curve in the circumferential direction before and after expansion of at least 0.7, as presently claimed.

Bates does nothing to overcome the deficiencies of Kashima. Bates is cited in the Final Office Action for the disclosure of water as a convenient and pollution-free means to quench steel and that water is capable of creating cooling rates within the range taught by Kashima. However, Bates does not disclose or suggest that the disclosed steel pipe should be heated at the austenite-ferrite dual-phase temperature region and then quenched <u>after</u> a steel plate is shaped into the disclosed steel pipe to obtain a ratio of the proportional limit of the compression stress-strain curve in the circumferential direction before and after expansion of at least 0.7, as presently claimed.

Therefore, Kashima and Bates, whether taken alone or in combination, do not disclose or suggest that <u>after</u> a steel plate is shaped into a steel pipe, the resulting steel pipe is heated at the austenite-ferrite dual-phase temperature region and then quenched, as is the presently claimed steel pipe to obtain a ratio of the proportional limit of the compression stress-strain curve in the circumferential direction before and after expansion of at least 0.7.

The presently claimed steel pipe has a ratio of the proportional limit of a compression stress-strain curve of the pipe in the circumferential direction before and after expansion of the steel pipe of at least 0.7 and a heat history that neither Kashima nor Bates disclose or suggest. The presently claimed steel pipe is significantly different from the steel pipe that one of ordinary skill in the art would obtain by following the combined disclosures of Kashima and Bates.

Similarly, Kami discloses a steel pipe that may be formed from a steel similar in composition to the steel base material used to make the steel pipe of the present invention. However, as with Kashima and Bates, Kashima does not disclose or suggest that <u>after</u> a steel plate is shaped into a steel pipe, the steel pipe is heated at the austenite-ferrite dual-phase temperature region and then quenched, as is the steel pipe of the invention, to obtain a ratio of the proportional limit of the compression stress-strain curve in the circumferential direction before and after expansion of at least 0.7, as presently claimed.

As discussed by Dr. Asahi in his Rule 132 Declaration, the Office Action cites paragraphs [0013], [0016], and [0030] of Kami for the disclosure of heating a pipe to 650° to 850°C and subsequently cooling the pipe. The Office Action apparently takes the position that any cooling is quenching. However, as discussed by Dr. Asahi, it is well known to those skilled in the steel making art that most disclosures of cooling are not disclosures of quenching. Cooling typically occurs slowly over an extended period of time. In contrast, as

stated by Dr. Asahi, quenching is performed rapidly, and requires rapid cooling, such as that obtained by spraying the heated steel with water or oil, or immersing the heated steel in water or oil. Quenching results in a very rapid decrease in the temperature of the heated steel.

An example of cooling that is not quenching is provided by the original Japanese disclosure of Kami in paragraph [0013] cited by the Office Action. In paragraph [0013], Kami discloses that an steel tube is heated to 650° to 850°C, subjected to 50 percent diaphragm rolling, and then cooled to 600°C at an average cooling rate of 2.0°C per second. As stated by Dr. Asahi, one of ordinary skill in the art will understand that an average cooling rate of 2.0°C per second is far too slow to be considered quenching. A typical average cooling rate for quenching is typically 30°C per second, and a minimum cooling rate for quenching is about 10°C per second.

In paragraphs [0016] and [0030] Kami discloses cooling heated pipe in various steps of the process disclosed in that reference. However, as stated by Dr. Asahi in his Rule 132 Declaration, the cooling disclosed in paragraphs [0016] and [0030] of Kami is not quenching.

Therefore, Kami does not disclose or suggest that <u>after</u> a steel plate is shaped into a steel pipe, the steel pipe should be heated at the austenite-ferrite dual-phase temperature region and then quenched, as is the steel pipe of the present invention. As stated by Dr. Asahi, the steel pipe disclosed by Kami will have a ratio of the proportional limit of a compression stress-strain curve of the pipe in the circumferential direction before and after expansion of the steel pipe that is significantly less than the presently claimed 0.7.

Kami does not disclose or suggest a steel pipe that has the heat history of the presently claimed steel pipe, and, thus, the presently claimed steel pipe is significantly different from the steel pipe that one of ordinary skill in the art would obtain from the disclosure of Kami.

The Office Action objected to the previously filed Rule 132 Declaration of Dr. Asahi for allegedly not calculating the proportional limit ratios of the steels tested in the experiments discussed in that Rule 132 Declaration to allow a comparison of the tested steels and the claimed range.

In response, Dr. Asahi again discusses the experiments described in his previously filed Rule 132 Declaration, and provides a discussion of the proportional limit ratios of the tested steels. Dr. Asahi has again submitted Figures A, B, and C, which were submitted with the previously filed Rule 132 Declaration.

Figure A provides a stress-strain diagram for a stress-strain test of a steel pipe in accordance with the present invention;

Figure B provides a stress-strain diagram for a stress-strain test for a steel plate having a steel composition in accordance with the present invention, Kashima, and Kami; and

Figure C provides a stress-strain diagram for a stress-strain test for a steel pipe that has not been heated and quenched, such as the steel pipes disclosed by Kashima and Kami.

Again, the X-axis, which is the strain axis, in each of the diagrams illustrated in Figures A, B, and C represents the same units. In Figure A, the strain axis is expressed as percent. In Figures B and C, the strain axis is expressed as a non-dimensional decimal. As stated by Dr. Asahi, it is readily apparent that the X-axis or strain axis of Figures A, B, and C represent the same units.

In the experiments discussed in the Rule 132 Declarations of Dr. Asahi, a steel plate was produced containing, in mass percent, 0.086 percent C, 0.21 percent Si, 1.19 percent Mn, 0.018 percent P, 0.006 percent S, 0.03 percent Al, 0.0035 percent N, and a balance of iron and unavoidable impurities; and

The steel plate was produced by heating a slab at 1,230°C; hot rolling at a finish temperature of 870°C; cooling at a cooling rate of 20°/second; then coiling at a coiling temperature of about 550°C; and

It was then determined that the steel base material of the steel plate had a dual phase structure substantially comprising a ferrite structure and fine martensite dispersed at the ferrite grain boundaries. The fine martensite had an area ratio of 15 percent.

As stated by Dr. Asahi, the steel plate had a composition that was substantially the same as the steel plates used to obtain the results provided in the examples of the present specification.

A steel pipe of the invention was fabricated from the steel plate discussed above, and <u>after</u> the steel pipe was fabricated from the steel plate the steel pipe was heated at the austenite-ferrite dual-phase temperature region, and the heated steel pipe was then quenched.

A test piece of the steel pipe, which, in accordance with the presently claimed invention, was heated and quenched, was subjected to a stress-strain test. The results of the stress-strain test of that steel pipe of the invention are provided in Figure A. As discussed by Dr. Asahi in his Rule 132 Declaration, Figure A shows that after a steel plate of the present invention is shaped into a pipe, then heated at the austenite-ferrite dual phase temperature region, and then quenched, the resulting steel pipe of the invention absorbs additional stress from a load after reaching the yield point stress. That is, a steel pipe formed from the steel plate of the invention that is heated and quenched in accordance with the invention exhibits plastic deformation or working.

As can be seen in Figure A, the yield point stress of the test piece of the steel pipe in accordance with the invention is about 400 MPa. That is, the steel pipe of the invention begins to yield to the stress applied to the pipe when the stress is about 400 MPa. However, the steel pipe of the invention continues to absorb stress until the stress exceeds 600 MPa. Failure of the test piece of the steel pipe in accordance with the invention does not begin to occur until the strain on the pipe is greater than 15 percent.

Thus, as stated by Dr. Asahi in his previously filed Rule 132 Declaration, Figure A shows that a steel pipe of the presently claimed invention that has been subjected to a specific heat treatment and then quenching after the steel plate is shaped into the steel pipe, does not begin to fracture when the stress reaches the yield point stress. Instead, the steel pipe of the present invention exhibits plastic working upon reaching the yield point stress, and continues to absorb stress as the stress increases.

In addition, the proportional limit ratio of the steel pipe of the invention used to obtain the results illustrated in Figure A will be at least 0.7, as presently claimed. The proportional limit ratio of the tested steel pipe must be at least 0.7, as the tested steel pipe had a composition that was substantially the same as the steel pipes of the invention used in the examples of the present specification, and was formed from a steel plate in the same manner as the steel pipes of the invention. As all of the exemplified steel pipes of the invention set forth in the present specification have a proportional limit ratio of at least 0.7, those skilled in the art will understand that the steel pipe of the invention of Figure A must also have a proportional limit ratio of at least 0.7. Contrary to the statement in the Office Action that the previously filed Rule 132 Declaration of Dr. Asahi does not provide a calculate proportional limit ratio for the steel pipe of Figure A, the value of the proportional limit ratio of that pipe must be at least 0.7. A pipe made from the same material in the same process must have the same properties.

Figure B provides a stress-strain diagram for the steel plate used to form the steel pipe of the invention that provided the results of the stress-strain test illustrated in Figures A and C. That is, the steel plate used to obtain the stress-strain diagram of Figure B has the same compositon as the steel plate used to form the steel pipe of the present invention used to obtain the results illustrated in Figure A and the same compositon as the steel plate used to obtain the results illustrated in Figure C, which corresponds to prior art steel pipes, such as that used to form the pipe disclosed in Kashima and Kami.

A test piece of that steel plate was subjected to a stress-strain test. Figure B shows that the tested steel plate absorbs additional stress from a load after reaching the yield point

stress, and, thus, exhibits plastic deformation or working. The steel plate has a yield point stress of about 400 MPa, and continues to absorb stress until the stress approaches 500 MPa at a strain of about 10 to 15 percent.

Figure C provides the results of a stress-strain test of a the steel pipe that was not heated and quenched in accordance with the present invention. The steel pipe was fabricated from the steel plate disclosed above in substantially the same manner as the steel pipe discussed above. Thus, the steel pipe subjected to the stress-strain test of Figure C is a prior art pipe, such as the pipe disclosed by Kashima and Kami, that was not both heat treated and then quenched after the steel pipe was fabricated from the steel plate. In his Rule 132 Declarations, Dr. Asahi refers to the steel pipe tested to obtain Figure C as a prior art steel pipe. In contrast to the steel pipe of the invention, the prior art steel pipe was not heat treated and then quenched after the steel plate was shaped into the steel pipe.

To obtain the results shown in Figure C, a test piece of the prior art steel pipe was subjected to a stress-strain test substantially the same as the stress-strain test of the test piece of the steel pipe test piece in accordance with the present invention described above. As discussed by Dr. Asahi, Figure C clearly shows that the prior art steel pipe, which was not heat treated and then quenched after being shaped into a pipe, does not absorb additional stress from a load after reaching the yield point stress, and, thus, does not exhibit plastic working or plastic deformation.

In contrast to the steel pipe of the invention, the prior art steel pipe begins to fracture immediately after reaching the yield point stress. As discussed by Dr. Asahi, as the prior art steel pipe fractures immediately after reaching the yield point stress, it is not possible to calculate a proportional limit ratio for the prior art steel pipe.

In contrast to the steel pipe of the invention, the prior art steel pipe does not exhibit any plastic working after reaching the yield point stress. At a yield point stress of a little more than 500 MPa and a strain of about 1 percent, the prior art pipe fails, and does not absorb any additional stress. Figure C shows that the stress absorbed by the prior art steel pipe reaches a maximum at about the yield point stress, and then fails. The prior art steel pipe is unable to absorb any additional stress, as does the steel pipe of the invention, which absorbed over 600 MPa of stress at a strain of over 15 percent.

As discussed by Dr. Asahi, the Office Action states that his previously filed Rule 132 Declaration does not establish that the results of the test discussed above are significant because the proportional limit ratio of the steel pipe of the invention and that of the prior art steel pipe are not calculated. However, those skilled in the art will understand from the

present specification that the proportional limit ratio of the steel pipe of the invention used to obtain Figure A must be at least 0.7, and that a proportional limit ratio for the prior art steel pipe cannot be calculated. Thus, the prior art steel pipe does not have a proportional limit ratio of at least 0.7, as presently claimed.

As stated by Dr. Asahi, as a result of having the proportional limit ratio of at least 0.7, the steel pipe in accordance with the present invention continues to absorb stress after reaching a yield point stress of about 400 MPa, such that the steel pipe in accordance with the invention exhibits plastic deformation or working to a maximum stress of over 600 MPa at a strain of over 15 percent. Thus, steel pipe in accordance with the present invention exhibits the ability to absorb stress at a stress that was over 50 percent higher then the yield point stress. Such an ability to absorb stress beyond the yield point stress is a clear indication of a relatively large proportional limit ratio.

In contrast to the steel pipe in accordance with the present invention, as a result of having the proportional limit ratio that is not at least 0.7, the prior art steel pipe failed to absorb any appreciable stress above the yield point stress of about 500 MPa, and immediately failed at the yield point stress with a strain of only about 1 percent. Such an inability to absorb stress beyond the yield point stress is a clear indication that the presently claimed steel pipe is significantly different from and clearly superior to the prior art steel pipe.

Similar results are illustrated in the Examples and Figures provided in the present specification, further showing that the presently claimed steel pipe provides unexpected results when compared to prior art steel pipe.

Thus, as discussed by Dr. Asahi, Figure A illustrates the results of a stress-strain test of a steel pipe in accordance with the present invention having a ratio of the proportional limit of the compression stress-strain curve in the circumferential direction before and after expansion of at least 0.7, as presently claimed. Figure C illustrates the results of a stress-strain test of a steel pipe that has not been both heated and quenched in the manner of the steel pipe in accordance with the present invention, and, thus, does not have a ratio of the proportional limit of the compression stress-strain curve in the circumferential direction before and after expansion of at least 0.7. A comparison of Figures A and C shows that the two steel pipes, although formed from steel plates having substantially similar compositions, but having different heat histories, exhibit very different stress-strain characteristics.

The analysis of Figures A and C provided by Dr. Asahi in his Rule 132 Declaration demonstrates that a steel pipe in accordance with the present invention is able to absorb stress that was over 50 percent higher then the yield point stress. In contrast, a prior art steel pipe

fails at the yield point, and cannot absorb any additional stress. Thus, the steel pipe in accordance with the invention has a Bauschinger effect that is less than the Bauschinger effect of the prior art steel, which differs from the steel pipe in accordance with the present invention only in that the prior art steel pipe lacks the heat treatment and quenching of the steel pipe in accordance with the steel pipe of the invention. A prior art pipe that has been expanded, i.e., subjected to circumferential tensile stress, in applications such as oil and gas wells will fail at a lower stress than will an expanded steel pipe in accordance with the present invention formed from the same type of steel plate having the same dimensions.

As a result, one of ordinary skill in the art following the disclosures of Kashima, Bates, and Kami, whether taken alone or in combination, would not obtain the presently claimed steel pipe, and would have no reason to make and/or use the presently claimed steel pipe.

Therefore, the cited references do not disclose or suggest the presently claimed steel pipe, and the present claims are not obvious over the cited prior art. Accordingly, it is respectfully requested that the Examiner withdraw the rejection of claims 7 to 12 under 35 U.S.C. §103(a) over Kashima and the rejection of claims 7 to 12 under 35 U.S.C. §103(a) over Kami.

Applicants thus submit that the entire application is now in condition for allowance, an early notice of which would be appreciated. Should the Examiner not agree with Applicants' position, a personal or telephonic interview is respectfully requested to discuss any remaining issues prior to the issuance of a further Office Action, and to expedite the allowance of the application.

A separate Petition for Extension of Time is submitted herewith. Should any other fees be due, however, please charge such fees to Deposit Account No. 11-0600.

Respectfully submitted,

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